Arthrodesis — Part I: The carpus

Greg Harasen

Arthrodesis (fusion) of a joint is an orthopedic salvage procedure most often performed in the carpus and tarsus (1). Part I in this series will deal with the indications, surgical procedure, and results of carpal arthrodesis, while Part II will take a similar look at the tarsus.

Arthrodesis of the carpus is most commonly indicated after an injury caused by hyperextension (2). Falling or other impact traumas that hyperextend the carpus can cause severe injury to the numerous small palmar carpal ligaments that support the 3 levels of carpal joints. These ligaments, along with the palmar carpal fibrocartilage, located on the palmar aspect of the carpometacarpal joint space, are the major supports that permit 10 to 12 degrees of extension at the antebrachiocarpal joint in the average standing animal (3). Patients present with varying severities of lameness, swelling, and pain, depending on the time that has elapsed since the injury. If they are weight-bearing, all will demonstrate some degree of plantigrade stance (3). Some patients with carpal hyperextension will present with a gradual onset of symptoms and no history of trauma. While pain and swelling will be minimal, these patients are exercise-intolerant on the affected limb. Although immune-mediated arthritides cause some of these hyperextensions (3,4), the more common cause is a degenerative condition of the palmar carpal ligaments seen in older, overweight, large-breed dogs (5,6). Other reasons for carpal arthrodesis include carpal fractures or dislocations where reduction and adequate joint stability cannot be achieved (Figure 1), severe carpal arthritis where medical therapy does not provide adequate pain-relief and limb function, and some cases of radial paralysis where the elbow can be extended (2,7).

Evaluation of patients with hyperextension, fractures, or dislocations of the carpus involves physical examination to determine the degree of joint instability, as well as taking lateromedial and dorsopalmar radiographs. Lateromedial radiographs taken when the joint is stressed lateromedially and is in maximum extension will often identify the joint level involved in the injury. The carpometacarpal joint is most commonly involved due to the key supporting function of the palmar carpal fibrocartilage found at this level. Instability at the radiocarpal joint is present in only 10% of cases with hyperextension (2,3). Lateromedial radiographs will also permit evaluation of the accessory carpal bone. The only tendon that provides significant carpal support during weight-bearing is the tendon of the flexor carpi ulnaris muscle, which inserts on the accessory carpal bone. Disruption of the ligaments attaching the accessory carpal bone to the intermedioradial and metacarpal bones results in proximal displacement of the accessory carpal bone (2,3).

Figure 1. Complete luxation of the radial carpal bone in a 4 year-old border collie herding dog. The dog had fallen from a 15-meter height while herding a flock of sheep.

Identification of the joint levels involved in carpal instability leads to the next thorny question: partial carpal arthrodesis or pancarpal arthrodesis? Since most hyperextension instabilities do not involve the radiocarpal joint, some argue that these cases should undergo only a partial carpal arthrodesis involving the intercarpal and carpometacarpal joints. Partial carpal arthrodesis results in little change in gait and can be accomplished with limited surgical equipment; cross-pin stabilization and cancellous bone grafting have been described (3). Pancarpal arthrodesis produces a change in gait; animals must learn to circumduct the limb during the forward swing phase of the gait, since the carpus can no longer be flexed. This is seldom a major problem.

Animal Clinic of Regina, 1800 Garnet Street, Regina, Saskatchewan S4T 2Z2.

Figures 2, 3. Postoperative views of the dog shown in Figure 1 after pancarpal arthrodesis with the carpal arthrodesis plate. Note the larger 3.5 mm screws in the radius and the 2.7 mm screws in the metacarpal bone.

Although the radiocarpal joint may not be involved in most hyperextension injuries, determining this is not always unequivocal in evaluation of stress radiographs. Partial arthrodesis in the presence of subtle or mild radiocarpal ligamentous pathology could lead to a subsequent breakdown and recurrence of hyperextension. Arthrodesis increases the stresses on adjacent joints, frequently resulting in degenerative joint disease, which would be a probable occurrence in the radiocarpal joint when a partial arthrodesis is performed (2,8). For these reasons, pancarpal arthrodesis is preferred, regardless of the level of carpal joint injury (2).

Plate stabilization of any arthrodesis provides the most substantial and reliable fixation. In the carpus, it presents several technical challenges. First, the most biomechanically sound location for a pancarpal arthrodesis bone plate would be on the palmar surface of the carpus. While a procedure to accomplish this has been described, it is technically very demanding (3). Second, plates that are sized appropriately for a dog's radius accept screws that are often too large for the carpal and metacarpal bones. Iatrogenic fracture of metacarpal bones is one of the most common complications in pancarpal arthrodesis with conventional bone plates (9). Conversely, the use of a smaller plate with screws that are appropriate for the metacarpal bones sacrifices plate strength and rigidity. Third, closure of skin and soft tissues over the distal end of a conventional plate can be difficult. All of these concerns have been addressed with the development of the carpal arthrodesis plate (CAP; Jorgensen, Loveland, Colorado, USA) (Figures 2,3). The plate comes in 3 sizes: small, medium, and large. The medium-sized plate, which is most commonly used and is suitable for most dogs between 15 and 40 kg, contains 9 plate holes. The proximal 4 holes accept 3.5 mm screws for attachment to the radius. The distal 4 holes accept 2.7 mm screws for attachment to the 3rd metacarpal bone. The central hole accepts either 3.5 mm or 2.7 mm screws for attachment to the radial carpal bone. The small-sized plate accepts 2.7 mm and 2.0 mm screws, while the large-sized plate accepts 3.5 mm screws in all holes and has a broader, heavier plate construction in the proximal portion, which has 5 holes. All but the central hole in the CAP are dynamic compression holes that allow compression at the arthrodesis site. The CAP is tapered and thinner at its distal end to minimize problems with soft tissue closure. The distal portion is longer than a conventional plate, so that more of the 3rd metacarpal bone is covered by the plate. The combination of greater plate coverage and smaller screws reduces the frequency of iatrogenic metacarpal fracture (6,9). The distal end of the plate is also constructed such that it provides 10 degrees of carpal extension when it is applied without any contouring.

Delaying carpal arthrodesis after severe hyperextension, fracture, or carpal luxation may be wise, since swelling can be severe and vascular compromise to the paw is possible. Several days in a padded bandage allows the swelling to resolve and detracts nothing from the end result (10). However, the urge to forego surgery and to leave severe hyperextension injuries, nonreducible carpal fractures, or unstable carpal luxations in a cast or bandage must be avoided. With external coaptation, the fibrous tissue formed around the joint is virtually never strong enough to support weight bearing (1–3,8,10).

The application of the CAP for pancarpal arthrodesis involves a dorsal approach to the distal extremity of the radius, carpus, and the 3rd metacarpal bone. While some sources advocate the use of a tourniquet proximal to the surgical site or an Esmarch bandage on the limb to provide a bloodless surgical site, the author has not found this necessary. Articular cartilage must be debrided from all the articular surfaces of the carpal joint. While high speed burrs have been advocated for this purpose, patient use of small bone rasps, currettes, osteotomes, and other similar hand instruments also works well. In addition, the author uses a small metal wood-working burr, sterilized in ethylene oxide, and attached to the chuck of a battery-powered drill. Presurgical preparation and draping must also include the proximal extremity of the ipsilateral humerus. An 1- to 2-cm incision is made over the greater tubercle and soft tissues are dissected until the bone is exposed. A hole is made in the greater tubercle for harvesting cancellous bone for a graft. This hole can be made with an intramedullary pin or drill bit in a Jacob's chuck or power drill. Cancellous bone is harvested with a bone curette and placed in a blood-soaked sponge or packed directly into the carpal joint spaces. While some procedures advocate placement of the CAP before grafting with cancellous bone, placing the bone graft first allows more complete access to all areas of the carpal joint spaces. Bone for grafting should be harvested until all carpal joint spaces have been filled.

Contouring of the CAP is seldom necessary, since it already provides 10 degrees of carpal extension. The surgeon can consider measuring the opposite antebrachiocarpal joint with a goniometer in the standing animal, preoperatively, to check for individual variation. If a standard bone plate is used, contouring to provide for 10–12 degrees of extension will be required. The central

Figure 4. A pancarpal arthrodesis in an 8-year-old cat, for which a 7-hole length of veterinary cuttable plate and 2.0 mm screws were used.

hole of the CAP should be centered over the radiocarpal bone; it is drilled and tapped first. The most distal hole is centered over the 3rd metacarpal bone and fixed next. Then the remaining plate holes are filled in: 1 or 2 holes on each side of the central hole are drilled, so as to provide compression of the arthrodesis. Closure of soft tissues and skin with absorbable monofilament materials is advisable, since the limb will be bandaged for an extended period. Postoperative swelling can be marked, so a soft padded bandage should be applied for 3 to 5 d. A cast or mason metasplint should then be applied for at least 8 wk or until radiographic evidence of significant joint fusion is present (1–3). While the CAP overcomes many of the challenges and potential complications of the procedure, placement of the plate on the dorsal joint surface makes it susceptible to cycling and breakage or screw migration, if unprotected weight-bearing is permitted in the early postoperative period.

Lameness and reluctance to use the limb after removal of the splint is not unusual, probably because there is a "learning curve" for the animal to adapt to locomotion without carpal flexion. In addition, cold conduction and soft tissue irritation at the distal end of radial plates are well documented in patients with fractures of the radius and could be factors in some arthrodesis cases. Soft tissue irritation, implant loosening, sepsis, or persistent lameness have been reported as reasons for having to remove the plate in 17% to 23% of patients with carpal arthrodesis (1,6). Barring major complications, removal of the plate should not be contemplated until 6 mo after the surgery.

Application of diagnostic and surgical principles to carpal arthrodesis in the cat behooves the surgeon to bear 2 points in mind. First, even the smallest CAP is too large for the cat's carpus. A 7- to 8-hole length of 2.0/2.7 mm cuttable plate (Veterinary Cuttable Plate, Synthes, Mississauga, Ontario) works well for most adult cats (Figure 4). Second, pancarpal arthrodesis eliminates the ability to supinate the manus, which is of little consequence in the dog but affects grooming behavior with that paw in the cat.

Most animals can be expected to return to near normal function after pancarpal arthrodesis. One report stated that 74% of 45 dogs returned to normal walking and running on the leg, but fully 97% were clinically improved to a degree that the owners expressed satisfaction with the procedure (2).

References

1. Denny HR, Butterworth SJ. A Guide to Canine and Feline Orthopedic Surgery. 4th ed. London: Blackwell Sci, 2000:415–419.
2. Parker RB, Brown SG, Wind AP. Pancarpal arthrodesis in the dog: A review of forty-five cases. Vet Surg 1981;10:35–43.
3. Piermattei DL, Flo GL. Handbook of Small Animal Orthopedics and Fracture Repair. 3rd ed. Philadelphia: WB Saunders, 1997; 344–348, 361–370.
4. Ralphs SC, Beale BS, Whitney WO, Liska W. Idiopathic erosive polyarthritis in six dogs (description of the disease and treatment with bilateral pancarpal arthrodesis). Vet Comp Ortho Traumat 2000;13:191–196.
5. Pedersen NC, Morgan, JP, Vasseur PB. Joint diseases of dogs and cats. In: Ettinger SJ, Feldman EC, eds. Textbook of Veterinary Internal Medicine. 5th ed. Vol 2. Philadelphia: WB Saunders, 2000:1867.
6. Li A, Gibson N, Carmichael S, Bennett D. Thirteen carpal arthrodeses using 2.7/3.5 mm hybrid dynamic compression plates. Vet Comp Orthop Traumatol 1999;12:102–107.
7. Okin R. Carpal arthrodesis in a cat with radial nerve damage. Fel Pract 1982;12:18–20.
8. McKee M. Intractably painful joints. In: Houlton JEF, Collinson RW, eds. Manual of Small Animal Arthrology. Gloucestershire: British Small Animal Veterinary Association, 1994:122–125.
9. Whitelock RG, Dyce J, Houlton JEF. Metacarpal fractures associated with pancarpal arthrodesis in dogs. Vet Surg 1999;28:25–30.
10. DeCamp CE. Dislocations. In: Olmstead ML, ed. Small Animal Orthopedics. St. Louis: Mosby, 1995:346–347.